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AMS Tracker Thermal Control Subsystem

TTCS Condenser High Pressure Test Report

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Summary

For the AMS experiment onboard the International Space Station a thermal control system, known as the Tracker Thermal Control System (TTCS) is being developed. The TTCS basically consists of a mechanically pumped two-phase loop, where heat is collected at two evaporators and rejected at two radiators. The loop contains carbon dioxide. Critical parts of the loop are protected against freezing, using thermostats and heaters. However, during (accidental) total power down of the experiment, some parts may freeze.

This document describes the proof (460 MPa/4,600 bar) and high pressure (1,000 MPa/10,000 bar) test conducted on test samples of the TTCS Inconel 718 condenser tube.

Contents

(18 pages in total)

1 Scope of the document

This document describes the proof (460 MPa/4,600 bar) and high pressure (1,000 MPa/10,000 bar) test carried out on test samples of the TTCS Inconel condenser tube.

2 References documents

	Title	Number	Date
RD-1	AMS02 TTCS Condenser Freezing Test Plan and Procedure	AMSTR-NLR-TN-022 Iss 2.1	26-08-2005
RD-2	TTCS Condenser Freezing Test Report	AMSTR-NLR-TN-039 Iss 3.0	23-08-2005
RD-3	TTCS Condenser Design	AMSTR-NLR-TN-045 Iss 1.1	Febr-2006
RD-4	Condenser Manifold Brazing Procedure	AMSTR-NLR-PR-004 Iss 1.0	May 2007
RD-5	High Press Sample Test procedure	AMSTR-NLR-PR-007 Iss 1.0	May 2007

3 Test Objective and background

3.1 Objective

The objective of the test is to verify by test the condenser tubes can withstand the MDP pressure of the condenser section with the safety factors for yield and burst as documented in RD-2.

3.2 Background

3.2.1 Maximum Design Pressure

In the condenser the extreme MDP of 3009 bar can occur by uncontrolled thawing of the CO_2 in the condenser tubes after freezing.

This event however, may occur only in the unlikely event the AMS02 experiment will have a total power down. Uncontrolled thawing in the condenser lines in the radiator can occur in between frozen parts. The thawing will start at a temperature of -55°C and can continue upto a maximum, calculated by thermal modelling, of -5°C. This will induce a maximum pressure of 300,9 MPa (3009 bar, see also RD-1 and RD-2).

4 Test Sample Description

The test sample consists of: 3 identical high pressure bended test samples (Inconel 718). The bends are representative to the FM condenser design

The 3 test samples are made from Inconel 718 and are bended with the same radii as the condenser design. Six representative bends are present in all three test samples.

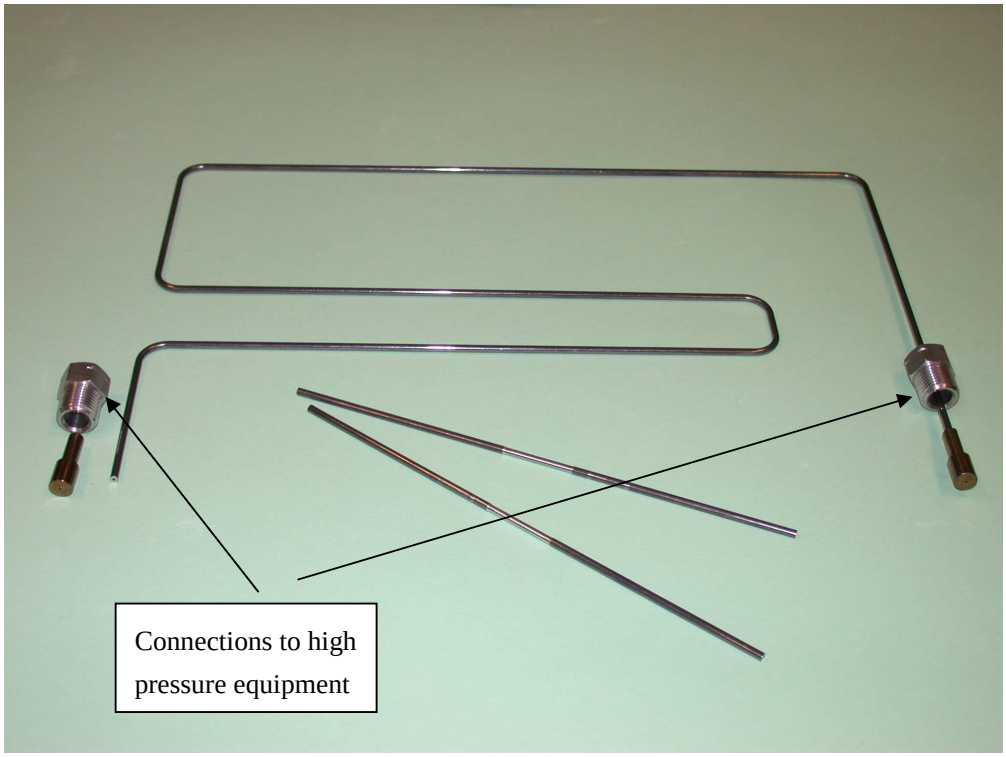


Figure 4-1: TTCS Condenser high pressure test samples (Inconel 718)

5 Proof and high pressure test execution

The pressure tests are performed by using high pressure equipment of Resato International BV, a manufacturer in the field of high pressure technology, developing high pressure components and systems. The test samples are connected to a high pressure unit (figure 5-1) which is capable to pressurize test units up to 10,000 bar, using IPA as working fluid. The samples (figure 5-2) are pressure tested according to the procedure RD-5. Pressure control is done by manual control of valves and the pressure is electronically logged by a pressure transducer and pc (figure 5-3).

The pressure test has been conducted twice, the first attempt (May 30, 2007) however, was unsuccessful due to leakage of the high pressure fitting connection which was brazed to the tube. Due to the temperature cycle required for solution heat treatment, a non optimal vacuum brazed connection was made. The brazed connections started to leak at a test pressure around 4000 bars, so the test pressure test was aborted. The problem was solved by modifying the high pressure fittings.

The modified fitting on the tube is used for pulling the butt-end of the Inconel tube to the counter part of the high pressure fitting. Now the high pressure seal consists of the tube butt-end tightly pulled on to a flat surface and the brazed connection is no longer part of the pressurized system.

The second pressure test (July-12-2007) was successful, however some minor problems occurred. Internal leakage of the high pressure unit caused the necessity of re-testing samples 2 and 3. Due to the internal leakage the 5 minutes at 10,000 bar requirement was not met and we were obliged to re-test the samples.

Figure 5-1: High pressure unit

Figure 5-2: Test sample in one half of protective enclosure.

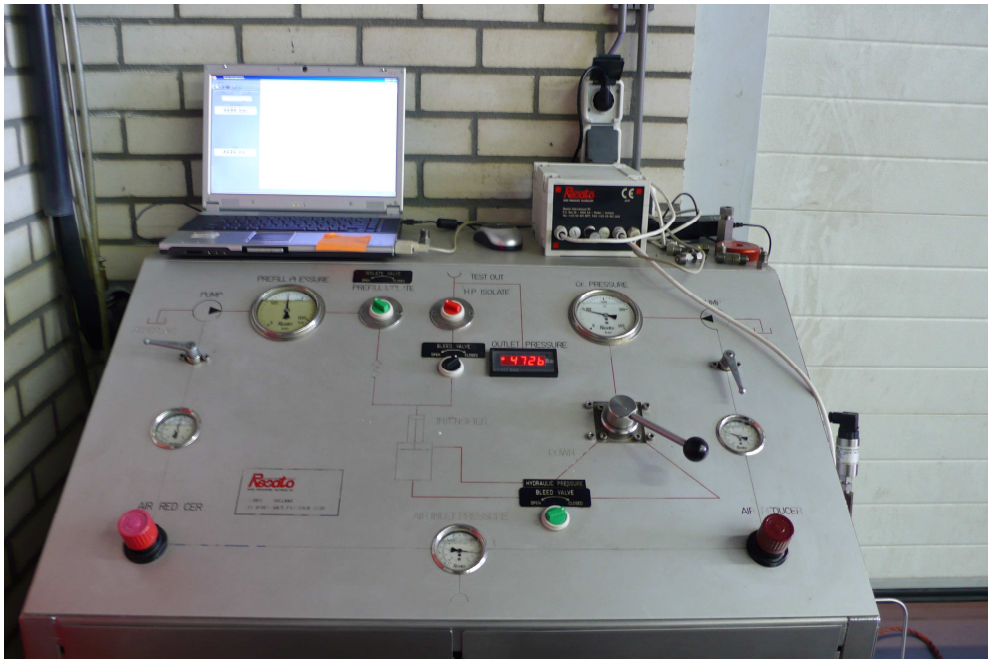


Figure 5-3 control panel of high pressure unit during test.

6 Result

All 3 samples passed the high pressure test. No burst, leakage or deterioration of the test samples were found after visual inspection.

Appendix A: Logsheets

5.4 TTCS High pressure test pro cedure sheet

Test sample indication: 1	Test engineer: A. P.	Test Date: 12/7/2007
Step	**Action to be taken**	**Result**
1.	**Type Condenser high pressure test sample numbers**	
2.	Connect sample number n (n=1,2 or 3) to the pressure system	1
3.	Install safety measures (protective metal enclosure, test inside bunker)	✓
4.	Increase pressure upto 460 MPa (4,600 bar)	5400 bar
5.	After a dwell time of 5 minutes (TBC) note pressure	5490
6.	Increase pressure upto 1,000 MPa (10,000 bar)	✓
7.	After a dwell time of 5 minutes note pressure	10100 bar / 99 cm Lar
8.	Release pressure with a steep DP/dt gradient	✓
9.	Perform steps 1-8 for sample 2 and 3	
10.	**General remarks and notes**	@ high pressure zone leakage at fittings, so difficult to maintain pressure

5.4 TTCS High pressure test pro cedure sheet

Test sample indication: 2	Test engineer: A. K	Test Date: 12/07/2007
Step	**Action to be taken**	**Result**
1.	**Type Condenser high pressure test sample numbers**	
2.	Connect sample number n (n=1,2 or 3) to the pressure system	2
3.	Install safety measures (protective metal enclosure, test inside bunker)	✓
4.	Increase pressure upto 460 MPa (4,600 bar)	4680
5.	After a dwell time of 5 minutes (TBC) note pressure	4700
6.	Increase pressure upto 1,000 MPa (10,000 bar)	✓
7.	After a dwell time of 5 minutes note pressure	10.000*
8.	Release pressure with a steep DP/dt gradient	✓
9.	Perform steps 1-8 for sample 2 and 3	
10.	**General remarks and notes**	

* after ca 2 min failure of pressure system

5.4 TTCS High pressure test procedure sheet

Test sample indication: 2 RE-RUN	Test engineer: A. P	Test Date: 12/02/2007
Step	**Action to be taken**	**Result**
1.	**Type Condenser high pressure test sample numbers**	
2.	Connect sample number n (n=1,2 or 3) to the pressure system	2
3.	Install safety measures (protective metal enclosure, test inside bunker)	✓
4.	Increase pressure upto 460 MPa (4,600 bar)	4640 bar
5.	After a dwell time of 5 minutes (TBC) note pressure	4760 bar
6.	Increase pressure upto 1,000 MPa (10,000 bar)	10340 bar
7.	After a dwell time of 5 minutes note pressure	10 000
8.	Release pressure with a steep DP/dt gradient	✓
9.	Perform steps 1-8 for sample 2 and 3	
10.	**General remarks and notes**	RE-RUN

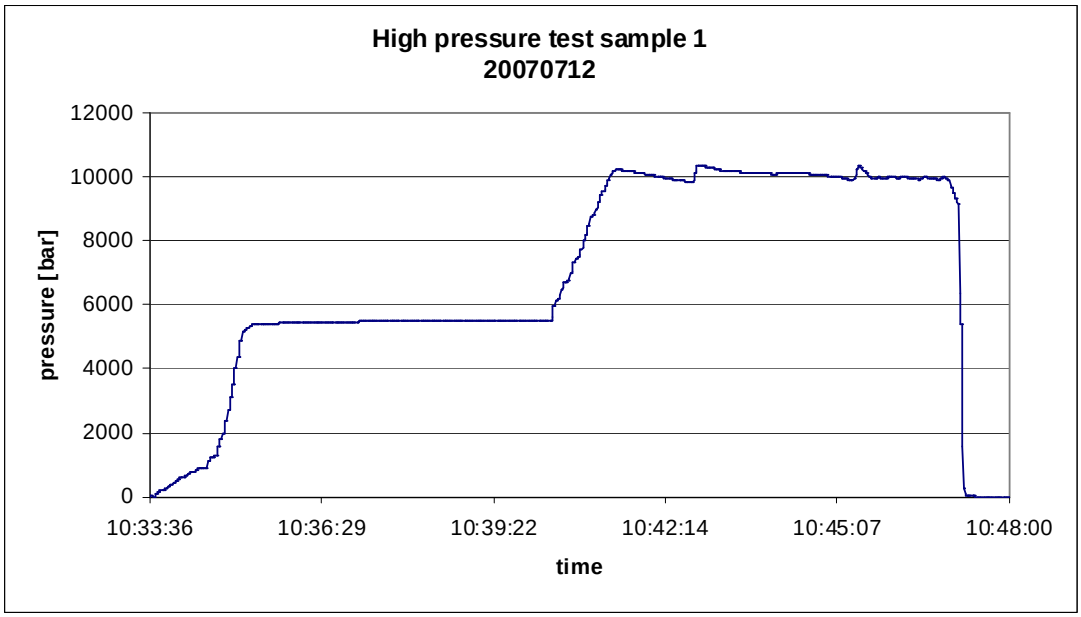
5.4 TTCS High pressure test procedure sheet

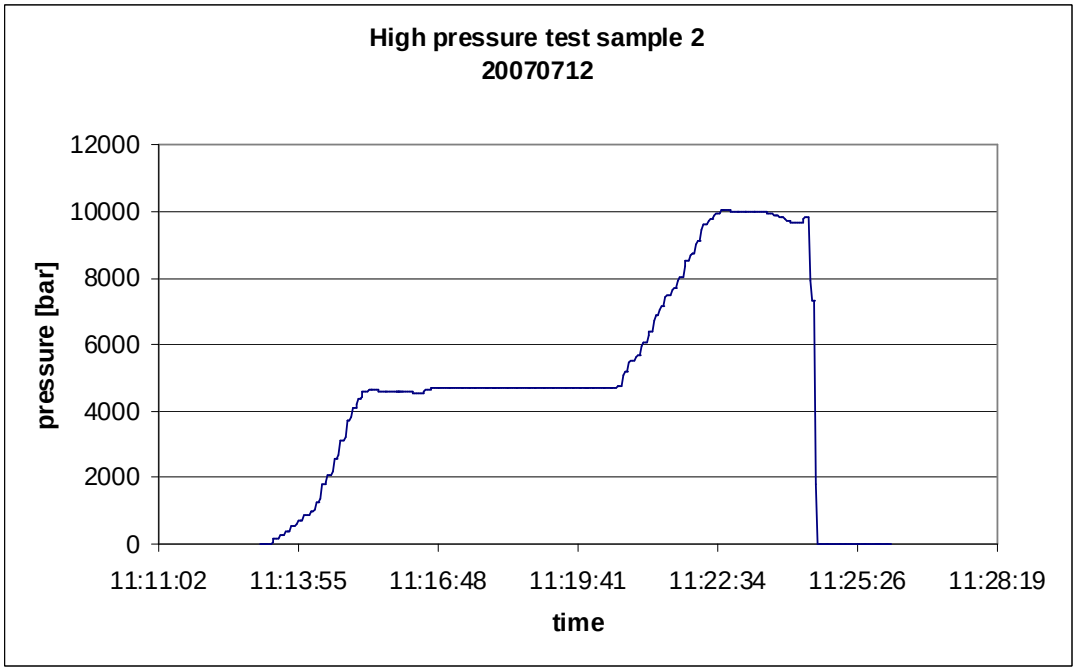
Test sample indication: 3	Test engineer: Aswin Pauw	Test Date: 12/7/2007	
Step	**Action to be taken**	**Result**	
1.	**Type Condenser high pressure test sample numbers**	3	RE-RUN
2.	Connect sample number n (n=1,2 or 3) to the pressure system	✓	✓
3.	Install safety measures (protective metal enclosure, test inside bunker)	✓	✓
4. *	Increase pressure upto 460 MPa (4,600 bar)	4720	4700
5.	After a dwell time of 5 minutes (TBC) note pressure	4740	4890
6.	Increase pressure upto 1,000 MPa (10,000 bar)	10030	✓ / 40000
7.	After a dwell time of 5 minutes note pressure	⊛	10270
8.	Release pressure with a steep DP/dt gradient	✓	✓
9.	Perform steps 1-8 for sample 2 and 3		
10.	**General remarks and notes**		RE-RUN

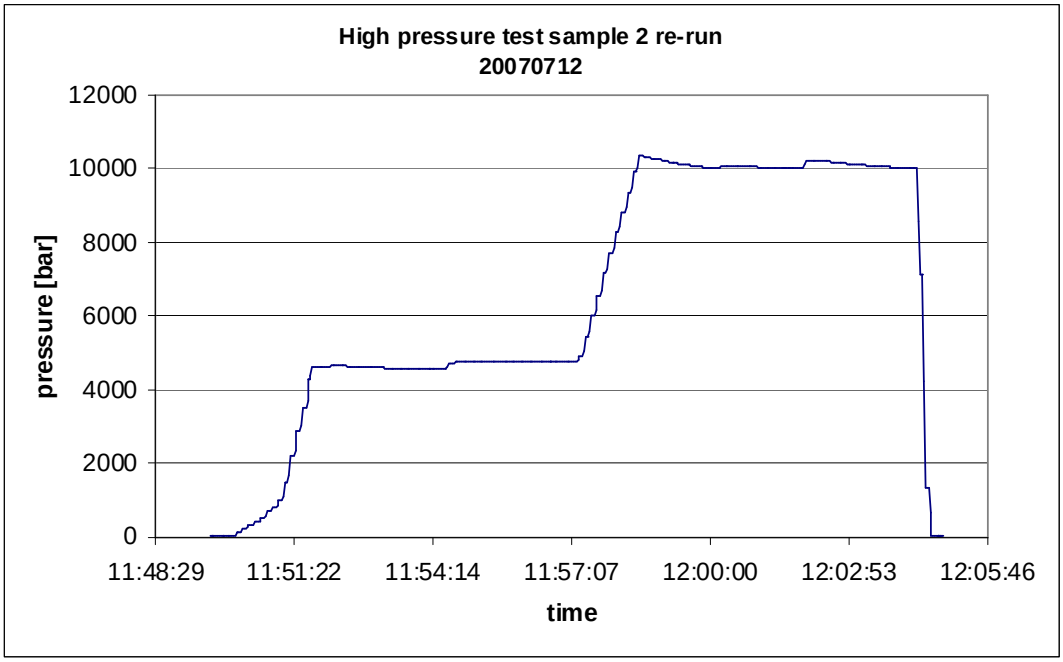
* increase : steps + 100 bar / 5 sec

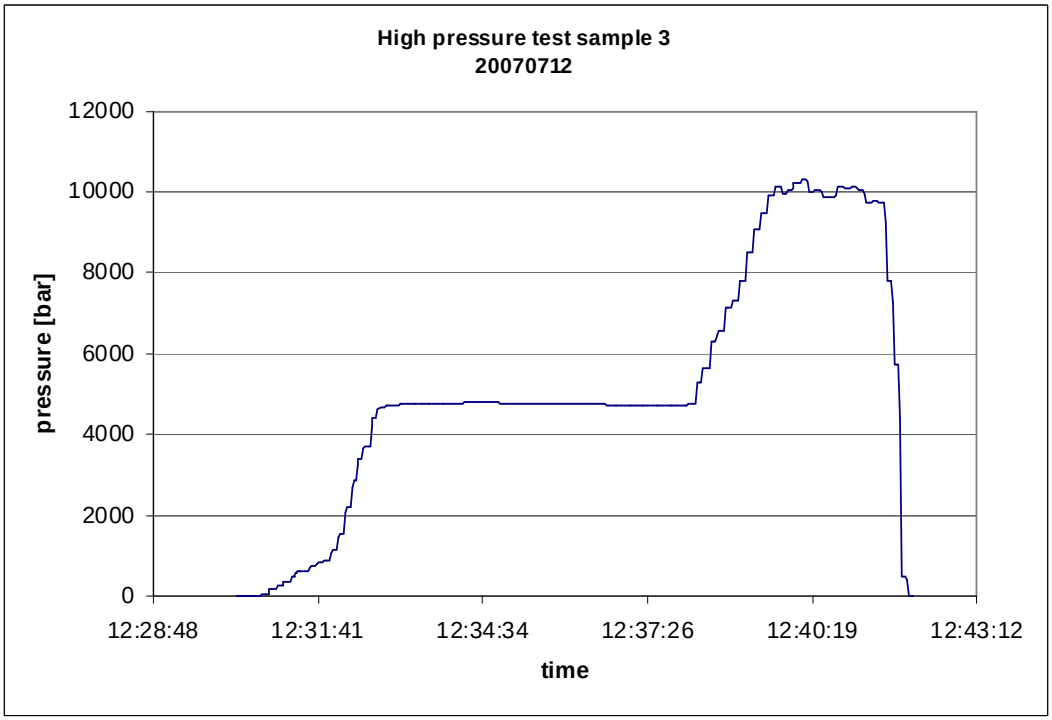
⊛ leakage pressure system after 3 min

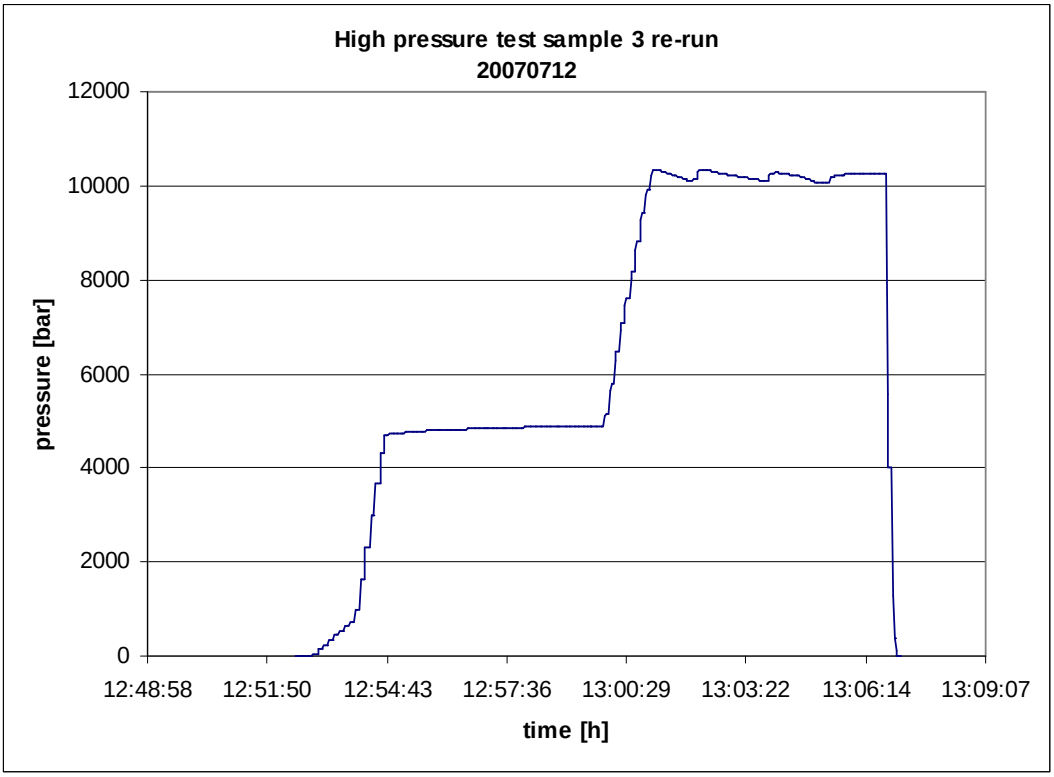
Pressure charts.






High pressure test sample 2 re-run
20070712
12000
10000
8000
6000
4000
2000
0
pressure [bar]
11:48:29
11:51:22
11:54:14
11:57:07
12:00:00
12:02:53
12:05:46
time


High pressure test sample 3
20070712
12000
10000
8000
6000
4000
2000
0
pressure [bar]
12:28:48
12:31:41
12:34:34
12:37:26
12:40:19
12:43:12
time



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